

Space weathering of olivine: Samples, experiments and modeling

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Olivine is a major constituent of chondritic bodies and its response to space weathering processes likely dominates the optical properties of asteroid regoliths (e.g. S- and many C-type asteroids). Analyses of olivine in returned samples and laboratory experiments provide details and insights regarding the mechanisms and rates of space weathering.

Analyses of olivine grains from lunar soils and asteroid Itokawa reveal that they display solar wind damaged rims that are typically not amorphized despite long surface exposure ages, which are inferred from solar flare track densities (up to 10^7 y) [1]. The olivine damaged rim width rapidly approaches ~ 120 nm in $\sim 10^6$ y and then reaches steady-state with longer exposure times. The damaged rims are nanocrystalline with high dislocation densities, but crystalline order exists up to the outermost exposed surface. Sparse nanophase Fe metal inclusions occur in the damaged rims and are believed to be produced during irradiation through preferential sputtering of oxygen from the rims.

The observed space weathering effects in lunar and Itokawa olivine grains are difficult to reconcile with laboratory irradiation studies and our numerical models that indicate that olivine surfaces should readily blister and amorphize on relatively short time scales ($< 10^3$ y). These results suggest that it is not just the ion fluence alone, but other variable, e.g. the ion flux that controls the type and extent of irradiation damage that develops in olivine [e.g. 2]. This flux dependence argues for caution in extrapolating between high flux laboratory experiments and the natural case.

Additional measurements, experiments, and modeling are required to resolve the discrepancies among the observations and calculations involving solar wind processing of olivine.

References: [1] Keller, L. P. et al. (2016) 46th LPSC abstract #2525. [2] Matsumoto, T. et al. (2015) LPI Workshop on Space Weathering, LPI Contribution No. 1878, 2045.